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Management of high-yielding bovines in the Indian scenario: A review

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Abstract

High-yielding bovines are central to sustaining India's growing dairy sector, yet their productive performance under field conditions often fails to reach genetic potential. This shortfall is mainly due to nutritional imbalances, heat stress, reproductive inefficiency, metabolic disorders and limitations in management practices prevalent in tropical and smallholder production systems. High-producing cattle and buffaloes experience intense metabolic stress, particularly during the transition and early lactation periods, which increases susceptibility to health disorders and compromises fertility and milk yield. Addressing these challenges requires a comprehensive, climate-resilient and system-based management approach tailored to Indian agro-climatic conditions.

This review critically examines major components of high-yielding bovine management in India, including nutritional strategies for optimizing energy and protein intake, transition period management, mineral and vitamin supplementation, reproductive efficiency, health and disease control, housing and heat stress mitigation, and milking and udder health practices. The potential role of precision dairy farming tools in improving monitoring, decision-making and animal welfare is also discussed. Emphasis is placed on integrating scientific feeding practices, preventive healthcare and environmental management to reduce physiological stress and enhance productivity.

The review concludes that sustainable management of high-yielding bovines in India depends on the adoption of evidence-based, location-specific interventions that balance productivity, animal welfare and environmental sustainability. Strengthening extension services, improving farmer awareness and promoting the judicious use of emerging technologies are essential for improving milk yield, reproductive performance and overall profitability of the Indian dairy sector.

Keywords: High yielder, nutrient, management, stress

Introduction

India ranks first in global milk production, yet the productivity of individual bovines remains considerably lower than that of developed dairy nations. This paradox is largely attributed to suboptimal management of high-yielding bovines under tropical and smallholder production systems. High-yielding cattle and buffaloes are characterized by elevated metabolic demands, making them more susceptible to nutritional imbalances, heat stress, reproductive disorders and metabolic diseases (Drackley, 1999; West, 2003) [1, 2]. In India, these challenges are further compounded by climatic variability, feed resource constraints and limited adoption of precision management tools. Therefore, scientific management strategies tailored to Indian agro-ecological conditions are essential for realizing the genetic potential of high-yielding bovines (Bernabucci *et al*., 2020) [3].

Characteristics of High-Yielding Bovines under Indian Conditions

High-yielding bovines in India mainly comprise crossbred cattle (Holstein Friesian × indigenous or Jersey × indigenous) and genetically improved buffaloes. These animals exhibit higher milk yields but reduced adaptability to thermal stress and disease challenges compared with indigenous breeds (Kadzere *et al*., 2002; Becker *et al*., 2022) [4, 5]. Elevated milk synthesis places enormous pressure on energy metabolism, often resulting in negative energy balance during early lactation (Bisinotto *et al*., 2013) [6]. Such physiological stress increases vulnerability to metabolic disorders, reduced fertility and compromised immune function (Sordillo and Aitken, 2009) [7].

Nutritional Management Strategies

Nutrition is the cornerstone of managing high-yielding

bovines. Indian feeding systems are predominantly based on low-quality crop residues, leading to deficiencies in metabolizable energy and protein (Bargo and Muller, 2004) [8]. High-producing animals require energy-dense diets to sustain lactation without excessive body reserve mobilization (Doepel *et al*., 2002) [9]. Strategic inclusion of concentrates, green fodders and high-quality silage improves rumen fermentation efficiency and milk yield (Khan and Loor, 2021) [10].

Bypass fat supplementation has been shown to enhance milk production and reproductive performance by increasing dietary energy density without disturbing rumen function (Bargo and Muller, 2004; Staples *et al*., 2005) [8, 11]. Similarly, rumen-protected protein improves amino acid availability for mammary tissue, thereby supporting higher milk synthesis (Khan and Loor, 2021) [10].

Transition Period Management

The transition period represents the most critical phase in the productive cycle of high-yielding bovines. Poor nutritional and managerial practices during this period predispose animals to ketosis, fatty liver and milk fever (Drackley, 1999; Leblanc, 2010) [1, 12]. Controlled energy feeding during late gestation helps prevent excessive fat deposition and metabolic stress after calving (Junnan *et al*., 2020) [13].

Adequate mineral and vitamin supplementation, particularly calcium, selenium and vitamin E, enhances immune competence and reduces postpartum disorders (Sordillo and Aitken, 2009; Khan and Loor, 2021) [7, 10]. Effective transition management has been consistently linked with improved peak milk yield and fertility (Doepel *et al*., 2002) [9].

Mineral and Vitamin Nutrition

Mineral deficiencies are widespread in Indian dairy systems and significantly affect productivity and reproduction in high-yielding bovines. Trace minerals such as zinc, copper and manganese play a vital role in enzyme activation, immune response and reproductive efficiency (Sordillo and Aitken, 2009) [7]. Chelated mineral sources exhibit higher bioavailability and have been associated with improved udder health and conception rates (Staples *et al*., 2005) [11].

Fat-soluble vitamins, particularly vitamins A, D and E, are essential for maintaining epithelial integrity, calcium homeostasis and antioxidant defense mechanisms (Leblanc, 2010) [12]. Their supplementation is especially important in intensively managed herds.

Heat Stress and Environmental Management

Heat stress remains one of the most significant constraints to high milk production in India. Elevated ambient temperature and humidity reduce feed intake, alter endocrine function and depress milk yield (West, 2003) [2]. Crossbred cattle are particularly vulnerable due to lower heat tolerance compared with indigenous breeds (Kadzere *et al*., 2002) [4].

Physiological adaptations to heat stress include increased respiration rate, altered nutrient partitioning and suppressed immune function (Bernabucci *et al*., 2020; Bagath *et al*., 2019) [3, 14]. Cooling strategies such as shade provision, fans, sprinklers and evaporative cooling systems have been shown to improve milk yield and reproductive performance (Ribeiro *et al*., 2016; Becker and Collier, 2021) [15, 16].

Reproductive Management

High milk yield is often inversely associated with reproductive efficiency. Negative energy balance during early lactation delays resumption of ovarian activity and reduces conception rates (Bisinotto *et al*., 2013) [6]. In Indian dairy herds, poor estrus detection further exacerbates reproductive inefficiency.

Nutritional adequacy, body condition score management and postpartum uterine health are essential prerequisites for improving fertility (Polsky and von Keyserlingk, 2019) [17]. Hormonal synchronization protocols and improved breeding management have demonstrated significant benefits in high-yielding dairy cattle (De Vries, 2006) [18].

Health and Disease Management

High-yielding bovines are more prone to metabolic and infectious diseases due to physiological stress associated with intensive milk production (Sordillo and Aitken, 2009) [7]. Mastitis remains the most economically important disease, adversely affecting milk yield and quality (Wedholm *et al*., 2020) [19].

Preventive health strategies, including vaccination, strategic deworming and regular health monitoring, significantly reduce disease incidence (Leblanc, 2010) [12]. Oxidative stress induced by high production levels can impair immune function, highlighting the importance of antioxidant supplementation (Sordillo and Aitken, 2009) [7].

Milking Management and Udder Health

Efficient milking management is crucial for sustaining milk yield and udder health. Improper milking practices increase the risk of intramammary infections and reduce milk quality (Keyserlingk *et al*., 2018) [20]. Consistent milking intervals, proper teat sanitation and post-milking teat dipping are proven strategies for mastitis prevention (Wedholm *et al*., 2020) [19].

Precision Dairy Farming and Emerging Technologies

Precision livestock technologies offer promising solutions for improving productivity and welfare of high-yielding bovines. Automated milk yield recording, activity sensors for estrus detection and environmental monitoring systems enable real-time decision-making (Wijewardana *et al*., 2021) [21]. Although adoption remains limited among smallholders, gradual integration of digital tools can substantially improve efficiency and sustainability of Indian dairy systems.

Animal Welfare and Sustainability

Animal welfare is intrinsically linked with productivity and longevity of high-yielding bovines. Stress reduction, comfortable housing and proper nutrition enhance immune function and production efficiency (Keyserlingk *et al*., 2018) [20]. Sustainable dairy management requires optimizing feed efficiency, minimizing environmental impact and improving animal resilience to climate stress (Bernabucci *et al*., 2020) [3].

Conclusion

Management of high-yielding bovines in India demands an

integrated approach encompassing nutrition, reproduction, health, housing and environmental stress mitigation. Addressing heat stress, transition period challenges and reproductive inefficiency through scientifically validated strategies can significantly enhance productivity and animal welfare. Adoption of precision dairy technologies and climate-resilient management practices will be crucial for ensuring sustainable growth of the Indian dairy sector.

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